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**CONTAMINATION OF OCEANS BY LONG-LIVED
RADIONUCLIDES ACCORDING TO THE RESULTS
OF SOVIET INVESTIGATIONS**

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I. Introduction

Contamination by radioactive substances particularly by Sr^{90} , can inflict irreparable harm to the resources of the Globe Ocean (1).

The research conducted up to this day on radioactive contamination of oceans was chiefly aimed at appraising its hazards. On the other hand, radioactive "tags" in the ocean have to be used to obtain new data on the processes occurring in it.

The present paper deals with the results of determination of Sr^{90} and Cs^{137} contents in the ocean water samples taken during the expeditions of the research ships "Vityaz" and "Mikhail Lomonosov" in 1959-1962.

The determination of Sr^{90} was effected by Y^{90} extracted from carbonate precipitate of sea water. The chemical yield of Sr was measured by the method of flame photometry. The content of Cs^{137} in the sea water was determined by cobalt nitrite precipitation with the subsequent reprecipitation as bismuth iodide and chloroplatinate Cs and by extraction as ferrocyanide compounds (2,3).

The activity of the isolated samples was measured on counters with a background of about 1 count/min. (4,5) and on a low-background gamma-spectrometer with liquid scintillator (6).

Pacific Ocean

Tables I and II present the data on Sr^{90} content in the waters of the Pacific Ocean in 1961, i.e. after a two-year interval in nuclear tests. It is interesting to make a comparison between these results and the ones of early observations.

25 YEAR RE-REVIEW

In 1954 local sites of radioactive contamination appeared on the surface of the Ocean near the proving grounds.

The concentration of Sr^{90} in these areas attained values up to 5800 disintegrations/min. per 100 litres (7). For the last years reduction of the maximum values and general levelling of Sr^{90} concentration in the surface waters of the Pacific Ocean was observed (8).

In 1961, as seen from table I, the original contamination sites were found to be washed out due to horizontal and vertical intermixing of waters and motion of radioactive nuclides in the waters.

The maximum concentration of Sr^{90} in the surface layer of the Ocean in 1961 did not exceed 122 disintegrations/min per 100 litres and the mean value of the results for waters of the northern hemisphere amounted to 50 ± 10 disintegrations/min. per 100 litres.

Simultaneously with reduction of heterogeneity in Sr^{90} distribution a further reduction of its mean concentration level in the surface layer in the western part of the Pacific Ocean is observed.

Along with this, in the eastern part of the Ocean some increase of concentration of Cs^{137} and consequently Sr^{90} was observed in the surface waters (10). Hence, it appears that there was a considerable shifting of Sr^{90} with waters in the west-east direction.

A two-years period was not sufficient for making equal the concentration of Sr^{90} in the northern and southern hemispheres. In the northern hemisphere waters in 1961 it was almost twice high than in the southern hemisphere.

The most interesting problem on vertical distribution of nuclear test products in the Pacific Ocean remains up to the present time poorly investigated.

The results given in table II allow to conclude that characteristics of the vertical distribution of Sr^{90} seem to differ in various points of the Ocean, and concentration decrease with depth occurs not always monotonously.

The speed at which radioactive contamination sites are washed away reduction of Sr^{90} concentration in the surface waters of the Pacific Ocean indicate that water exchange between various parts of the Ocean in the northern hemisphere and between various depths does not take place as slowly as believed before.

Indian Ocean

The data on concentration of Sr^{90} in surface waters of the Indian Ocean are presented in tables III and IV.

The most typical feature of radioactive contamination of the Indian Ocean is the more or less uniform distribution of Sr^{90} on the surface of the Ocean up to 40° latitude South. The resultant values of concentration fluctuate about 24 ± 4 disintegrations/min per 100 litres. In view of the fact that the northern hemisphere accounts for but an insignificant part of the area of the Indian Ocean, the difference in the level of contamination of water in the north and the south, observed in other oceans, could not manifest itself here to the same extent.

The comparison of concentration of Sr^{90} in the surface waters with radioactive contamination of the air overwater layer in the north part of the Indian Ocean (II) indicated that mostly the increase of fragment content in the air leads to the increase of Sr^{90} concentration in the water. This correlation, however, is not absolute due to the complex mechanism of fragment migration in the Ocean, which assumes predomination of one process or the other depending on conditions.

It is well known that different density of radioactive fall-out along the meridian is observed on the surface of land even within one, in particular, the southern hemisphere (II). It may be supposed that the density of radioactive fall-out on the surface of the Indian Ocean also depends on the latitude. Then the data of table III testify to the existence of a considerable exchange of surface waters between various regions levelling of Sr^{90} concentration. Biological factors as well as hydrological ones are of great importance in Sr^{90} migration. Radiochemical analysis of corals and shell-fish collected in shoal-water in various regions of the northern part of the Indian Ocean showed a considerable increase of specific activity of Sr^{90} in comparison with that (per 1 g. of stable Sr) in the surface waters; it indicates that there is a reservoir of Sr^{90} conservation in the Ocean due biological precipitation of carbonates.

The specific activity of shell-fish was 98 disintegration/min/g of stable Sr (average from 12 samples), of corals - 61 disintegrations/min/g of stable Sr (average from 10 samples).

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The determination of migration speed of Sr^{90} measurements were made in the surface layer of globi gerina ooze taken in the point $16^{\circ}58'$ latitude north, $67^{\circ}30'$ longitude east at the depth 4000 m. The activity of Sr^{90} was 5-6 disintegrations/min (100 g of dry ground). This indicates a rather high speed of vertical migration of Sr^{90} being just with biogenous character (skeletons of plankton foraminifera).

Proceeding from these data one can speak of a notable vertical transfer. The activity of Sr^{90} is observed practically at all depths. The transfer coefficient is variable, the factors causing this transfer are of physicohydrological and biogenous character.

Atlantic Ocean

Table Y presents the results of determining the concentration of Sr^{90} in the surface waters of the Atlantic Ocean for the period between September 1959 and December 1962.

However, in view of the fact that individual values in each ocean region do not differ greatly from one another, an averaging of the resulting data was made so as to trace the general nature of Sr^{90} change concentration in the surface layer.

For the sake of comparison, published data referring to 1954-1958 were used (I2, I3, I4). The following pattern is given for the northern part of the Atlantic Ocean:

1954 - I8	disintegrations/min per 100 l (I2)	single value
1955 - II2	"	(I2) "
1956 - I2	"	(I2, I3) "
1957 - I0	"	(I2, I4)
1958 - 8	"	(I4)
1959 - I6	"	(the present paper)
1960 - 2I	"	"
The first six months of 1961 - I4	"	"
The last six months of 1961 - 23	"	"
end of 1962-24	"	"

These results lead to the conclusion that despite the uninterrupted increase of deposited Sr^{90} , the concentration of Sr^{90} in the surface layer changes very slightly.

Of interest is the increase in the last six months of 1961 in connection with sharp rise in the intensity of the fall-out.

It may be presumed that the concentration of Sr^{90} in the surface layer of water rises during the periods of an increased rate of fall-out and drops when the rate of fall-out diminishes.

There is no doubt that the absence of any substantial rise in the concentration of Sr^{90} in the surface waters testifies to the intensive removal of Sr^{90} from the surface layer of the Ocean to deeper layers.

In the waters of the tropical zone of the Atlantic Ocean, the concentration of Sr^{90} proved in 1961 and 1962 1,6 times lower than in the waters of the northern part.

An appreciable rise in concentration in 1962 as compared with the first six months of 1961 was exhibited there more vividly than in the northern part.

In the first six months of 1961, several determinations of the content of Cs^{137} were made in the surface waters of the Atlantic Ocean. The results are given in Table VI. All the explored points, with the exception of one, belong to the tropical part of the Ocean. The average value for the points amounted to 20 disintegrations/min per 100 litres. In the same zone and for the same time period, the concentration of Sr^{90} (Table V) amounted to 9 disintegrations/min per 100 litres. The ratio of these figures (2.2) quite approximates that of the activities of Cs^{137} and Sr^{90} , peculiar of fission products.

The results of measurements of Sr^{90} concentration of various depths are given in Table VII. The surface layer down to 75-100 m generally has the same concentration of Sr^{90} in all horizons as in the Indian Ocean. With a greater depth, the concentration, as a rule, diminishes but not always uniformly.

This may occur where waters at a depth may have come down from the areas of a greater contamination. Such a drop in the concentration of Sr^{90} in proportion to depth attests that the spreading of this radionuclide to the depth is due not only to turbulent diffusion, but also to other processes.

The results given in the last column of Table VII indicate that in a layer of water down to depths of 500 to 1,000 m, the reserve of Sr^{90} at the explored points of the Ocean are rather great, far exceeding those deposited on land. This phenomenon should be taken into account when estimating the world reserve inventory of Sr^{90} (16).

Along with the open part of the Atlantic Ocean, samples of water were also taken in its closed seas: the Baltic Sea, the North Sea, the English Channel, the Mediterranean Sea, the Sea of Marmora and the Black Sea. It has been established that the concentration of Sr^{90} in these seas is almost double that in the open ocean at the same latitudes. Evidently this is accounted for by the smaller volume of the water mass accessible for the intermixing of Sr^{90} fallen out: the seas have no intensive exchange with less contaminated tropical water masses.

Conclusion

The results presented in this paper of determining radioactive contamination of the oceans cover rather great regions of the water space of each of them. Nevertheless, the number of explored points for these vast spaces should be considered quite insignificant. Publication of additional works on studies of radioactive contamination of oceans will apparently permit to present a more detailed picture of radionuclide distribution.

From the data on the concentration of Sr^{90} and its changes a notable speed of exchange is observed. Vertical distribution of this radionuclide indicates that it is difficult to regard deep waters as being isolated from the surface.

The research of the years in future includes the task of mastering the mechanism of horizontal and vertical transfer of artificial radionuclides in oceans.

But it is already clear now that the high speed of exchange raises doubts regarding the possible burial of waste of the atomic industry and transport in oceans.

Table I
Concentration of Sr^{90} in the surface waters
of the Pacific Ocean in 1961

Data	Coordinates		Sr^{90} act- ivity dis/min per 100 litres	Data	Coordinates		Sr^{90} act- ivity dis/min per 100 litres
	Latitude	Longitude			Latitude	Longitude	
I96I	N	E			N	E	
07.04	04°13'	128°59'	43±7	02.II	12°51'	176°06'	22±6
09.04	10°24'	130°23'	38±4	03.II	11°15'	176°16'	63±11
10.04	14°00'	130°32'	35±9	04.II	09°41'	176°03'	32±9
11.04	17°50'	130°52'	42±9	04.II	07°57'	175°57'	59±12
12.04	21°13'	130°45'	124±33	05.II	05°58'	176°04'	44±9
13.04	25°31'	130°58'	62±11	07.II	03°58'	176°08'	53±10
14.04	29°33'	131°00'	40±7	07.II	01°57'	176°06'	31±5
15.08	34°54'	165°27'	21±10	08.II	00°50'	176°02'	86±7
	N	W			S	W	
03.09	20°59'	158°11'	57±11	09.II	00°03'	176°07'	22±6
11.09	13°58'	140°25'	79±14	10.II	00°20'	176°07'	18±4
12.09	12°07'	140°38'	32±6	11.II	03°58'	176°04'	38±12
14.09	10°29'	140°00'	26±4	13.II	08°01'	175°57'	30±7
16.09	05°57'	139°57'	20±4	14.II	10°04'	176°00'	37±8
21.09	00°00'	140°02'	64±10	14.II	12°07'	175°59'	21±5
	S	W		16.II	14°00'	176°08'	30±8
25.09	05°02'	139°54'	43±8		S	E	
01.I0	17°50'	140°17'	24±4	23.II	11°58'	170°20'	15±3
03.I0	18°04'	148°43'	21±6	24.II	08°46'	166°41'	36±13
15.I0	13°02'	154°01'	34±5	26.II	03°46'	162°01'	51±13
16.I0	09°58'	154°02'	15±4		N	E	
18.I0	06°58'	154°02'	37±11	27.II	00°18'	162°30'	49±8
19.I0	05°03'	154°11'	20±5	28.II	01°22'	162°43'	30±5
21.I0	00°04'	154°09'	54±17	01.I2	06°33'	161°57'	94±15
24.I0	06°26'	153°49'	53±11	02.I2	07°39'	161°55'	86±14
26.I0	09°46'	153°54'	54±10	07.I2	16°25'	160°01'	87±15

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29.10	12 ⁰ 43'	159 ⁰ 03'	29±6	08.12	21 ⁰ 55'	155 ⁰ 35'	24±14
30.10	13 ⁰ 02'	165 ⁰ 21'	27±6	09.12	25 ⁰ 54'	151 ⁰ 53'	127±19
31.10	13 ⁰ 05'	170 ⁰ 21'	33±7	12.12	34 ⁰ 10'	141 ⁰ 27'	58±11

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Table II

Concentration of Sr^{90} in deep waters
of the Pacific Ocean, 1961

Data	Coordinates	Horizon mm	Sr^{90} activity disintegrations/ min per 100 l
9.04.1961	$10^{\circ}24'$ n.lat $130^{\circ}23'$ E.long	0	38 ± 4
		900	1.4 ± 1.0
		3000	14 ± 4
12.04.1961	$21^{\circ}13'$ n.lat $130^{\circ}45'$ E.long	0	124 ± 33
		900	9 ± 1
		5500	4 ± 1

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Table III

Concentration of Sr^{90} in the surface
waters of the Indian Ocean

Data	Coordinates		Sr^{90} act- ivity dis/min per 100 litres	Data	Coordinates		Sr^{90} act- ivity dis/min per 100 litres
I959	S.lat	E.long			n.lat	E.long.	
3.II	8°00'	109°40'	30±2	25.I0	14°44'	50°02'	20±5
5.II	10°20'	107°40'	36±3	28.I0	11°11'	52°13'	25±8
25.II	7°04'	99°42'	18±1	29.I0	10°19'	53°14'	18±6
29.II	16°02'	99°48'	22±1	31.I0	9°23'	54°56'	21±4
30.II	15°52'	104°50'	38±2	1.II	9°33'	57°08'	41±10
2.I2	23°39'	113°41'	28±2	3.II	15°23'	58°23'	49±10
17.I2	30°21'	89°53'	15±1	5.II	22°23'	59°53'	12±3
21.I2	16°09'	90°18'	36±3	8.II	22°49'	62°03'	14±2
				10.II	15°03'	62°00'	13±3
I960	n.lat.	E.long					
7.0I	5°15'	84°57'	18±2	13.II	8°40'	61°54'	32±5
	S.lat.	E.long.		15.II	3°25'	62°06'	23±5
10.0I	0°22'	85°19'	23±2		S.lat	E.long.	
15.0I	16°58'	67°30'	20±2	17.II	0°55'	62°33'	21±5
19.0I	8°27'	75°50'	15±1		n.lat	E.long.	
	n.lat.	E.long.		21.II	6°59'	65°57'	28±4
27.0I	6°52'	76°12'	6±1	26.II	19°15'	65°56'	20±5
4.02	10°46'	75°48'	5±1	12.I2	0°00'	70°52'	24±5
					S.lat.	E.long	
I960	S.lat	E.long.		14.I2	3°56'	73°10'	41±9
12.02	3°02'	65°02'	20±1	18.I2	10°40'	70°59'	21±7
16.02	8°52'	67°30'	19±1	20.I2	16°42'	70°58'	36±7
19.02	15°56'	67°23'	17±1	22.I2	24°04'	71°17'	31±7
22.02	16°10'	52°42'	6±2	24.I2	30°00'	71°22'	18±9
2.03	14°51'	53°01'	17±1	26.I2	36°06'	71°18'	8±3
	n.lat.	E.long.		27.I2	39°24'	71°19'	19±4
26.03	5°04'	58°07'	38±3	29.I2	31°50'	80°35'	23±6
2.04	14°03'	68°17'	44±2	31.I2	24°44'	83°03'	10±5

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I3.04	I6 ⁰ 25'	6I ⁰ 5I'	20±3				
I96I	S.lat	E.long					
I0.0I	I ⁰ 57'	83 ⁰ 03'	33±5	28.02	n.lat. I8 ⁰ 03'	E.long. 90 ⁰ 54'	I3±3
	n.lat	E.long.		6.03	9 ⁰ I4'	93 ⁰ 40'	56±II
24.0I	4 ⁰ 22'	83 ⁰ 05'	I4±4	I0.03	0 ⁰ 56'	92 ⁰ 35'	46±9
28.0I	I3 ⁰ 17'	83 ⁰ 03'	40±9				
3I.0I	I8 ⁰ 58'	87 ⁰ 00'	28±6	I3.03	0I ⁰ 00'	96 ⁰ 56'	33±6
2.02	I3 ⁰ 37'	86 ⁰ 53'	6±3	I7.03	5 ⁰ I7'	I00 ⁰ 37'	23±I0
5.02	6 ⁰ 62'	87 ⁰ 02'	24±4	20.03	I3 ⁰ 40'	I04 ⁰ 49'	34±I0
I4.02	II ⁰ 04'	92 ⁰ 02'	20±6	22.03	8 ⁰ I0'	I04 ⁰ 39'	I9±3

Table IV

Concentration of Sr^{90} in the deep waters
of the Indian Ocean

Data	Coordinates	Horizon	Sr^{90} activity disintegrations/min per 100 litres
		m	
3.11.59	$8^{\circ}00'$ S.lat. $109^{\circ}40'$ E.long.	0	30 ± 2
		300	25 ± 2
5.11.59	$10^{\circ}20'$ S.lat. $107^{\circ}40'$ E.long.	0	36 ± 3
		3000	2 ± 1
		6200	3 ± 1
17.12.59	$30^{\circ}21'$ S.lat. $89^{\circ}53'$ E.long	0	15 ± 1
		100	20 ± 3
		1000	4 ± 1
21.12.59	$16^{\circ}09'$ S.lat. $90^{\circ}18'$ E.long	0	36 ± 1
		100	17 ± 1
		1000	10 ± 1
		4000	3 ± 1
10.01.60	$0^{\circ}22'$ S.lat. $85^{\circ}19'$ E.long	0	23 ± 2
		100	24 ± 1
		1000	10 ± 1
19.01.60	$8^{\circ}27'$ S.lat. $75^{\circ}50'$ E.long	0	15 ± 1
		47	16 ± 1
		200	9 ± 2
		1000	4 ± 1
27.01.60	$6^{\circ}52'$ n.lat. $76^{\circ}12'$ E.long	0	6 ± 1
		200	6 ± 1
		1860	9 ± 1
12.02.60	$3^{\circ}02'$ n.lat. $65^{\circ}20'$ E.long	0	20 ± 1
		3500	4 ± 1
19.02.60	$15^{\circ}56'$ S.lat. $67^{\circ}23'$ E.long	0	17 ± 1
		150	21 ± 1
2.04.60	$14^{\circ}03'$ n.lat. $68^{\circ}17'$ E.long	0	44 ± 2
		200	58 ± 3

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Table V

**Concentration of Sr⁹⁰ in the surface
waters of the Atlantic Ocean, 1959-1962**

Data	Coordinates		Sr ⁹⁰ act- ivity dis/min per 100 litres	Date	Coordinates		Sr ⁹⁰ act- ivity dis/min per 100 litres
	Latitude	Longitude			Latitude	Longitude	
1959	North atlantics			1961	n	w	
	n	w		17.03	31°08'	10°34'	II
16.09	36°50'	58°28'	10	19.03	25°03'	16°58'	II
21.09	36°52'	68°12'	23	17.06	27°03'	30°03'	2I
				17.06	29°56'	30°00'	II
average according to observations in 1959			16	1962	n	w	
1960	n	w		26.12	33°59'	08°59'	25
22.01	45°48'	13°56'	60	Average according to observations at the end of 1962			24
23.01	43°02'	21°04'	9	1961	n	w	
24.01	37°33'	37°49'	9	20.06	39°55'	29°57'	20
31.01	33°07'	50°36'	18	20.06	39°57'	39°57'	17
03.02	28°39'	62°18'	23	22.06	43°13'	21°26'	9
03.02	28°39'	62°18'	28	25.06	50°10'	02°26'	12
03.02	28°39'	62°18'	28	Average according to observations of the first six months of 1961			14
10.02	27°03'	66°25'	9	27.09	41°37'	36°03'	14
13.02	28°14'	76°20'	7	27.09	41°37'	36°03'	40
16.02	31°57'	78°18'	10	13.09	37°33'	58°37'	18
21.02	38°59'	71°59'	53	15.09	37°33'	58°37'	17
23.02	37°32'	70°15'	10	16.09	37°51'	58°07'	19
04.04	54°52'	13°51'	12	17.09	37°51'	58°09'	16
average according to observations in 1960			21	18.09	37°51'	58°07'	15
				20.09	39°29'	62°55'	25
				21.09	39°29'	62°55'	30

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22.09	39°29'	62°55'	29
25.09	43°20'	52°00'	25
25.09	45°50'	51°30'	19
07.10	44°20'	52°11'	26

Average according to
observations of the last
six months of 1961 23

1962	n	w	
20.10	38°22'	10°16'	24
25.10	27°22'	14°07'	24
24.12	25°21'	15°48'	18
25.12	29°04'	12°39'	27

1961	n	w	
09.06	06°20'	30°06'	6
09.06	06°20'	30°06'	11
12.06	11°01'	29°56'	16
12.06	11°00'	29°51'	8
15.06	20°01'	30°00'	10
15.06	21°24'	30°03'	11

Average according to
observations of the first six
months of 1961 9

Equatorial atlantics

1962	n	w	
22.03	16°58'	20°29'	15
27.03	11°00'	18°15'	6
04.04	00°17'	20°19'	13
07.04	00°03'	15°04'	16

	S	W	
11.04	00°21'	04°26'	10
11.04	00°21'	04°26'	4
02.05	10°03'	20°33'	6
02.05	10°03'	20°33'	6
05.05	17°17'	27°13'	13
06.05	20°01'	30°03'	8
07.05	20°01'	30°03'	5
07.05	20°01'	30°03'	7
29.05	16°25'	30°03'	11

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29.05	16°27'	30°01'	6
30.05	11°18'	30°00'	6
31.05	09°47'	30°03'	6
03.06	04°04'	30°08'	8
04.06	01°42'	30°00'	4
04.06	01°42'	30°00'	7
05.06	02°02'	30°00'	18

1962	S	W	
13.12	16°02'	34°00'	10
13.12	16°02'	34°00'	9

	n	w	
16.12	04°35'	27°27'	13
12.12	00°50'	25°27'	10
22.12	16°30'	20°20'	18
23.12	20°52'	18°40'	9

Average according to
observations at the end
of 1962 16

1962	n	w	
26.10	20°29'	17°27'	17
28.10	14°09'	18°14'	16
31.10	09°00'	17°55'	21
01.11	06°00'	18°10'	11
08.11	01°05'	18°10'	27

	S	W	
11.11	01°00'	25°10'	33
17.11	02°00'	30°18'	17
20.11	08°25'	34°55'	16
20.11	08°25'	34°55'	16

21.II	10°39'	38°05'	I3
22.II	12°15'	31°50'	I6
23.II	12°04'	34°54'	I0
28.II	16°00'	33°21'	I6
II.I2	22°14'	39°51'	I3
II.I2	22°14'	39°51'	I9

South atlantics

1961	S	W	
11.05	23°03'	29°54'	I0
12.05	29°58'	30°05'	I6
12.05	29°51'	30°17'	4
12.05	29°51'	30°17'	9
15.05	25°17'	40°00'	7
16.05	25°18'	39°58'	I3

Average

I0

Table VI

Concentration of Cs^{137} in the surface
waters of the Atlantic Ocean

Data	Coordinates	Cs^{137} activity disintegrations/min per 100 l
19.03.1961	24°30' n.lat 16°57' w.long	30
22.03.1961	20°27' " " 17°50' " "	25
7.04.1961	00°02' S.lat. 13°41' " "	24
7.05.1961	20°01' " " 30°07' " "	17
31.05.1961	09°46' " " 30°02' " "	8
11.06.1961	10°59' S.lat. 29°57' " "	20
15.06.1961	21°24' " " 30°03' " "	22
average		21

Table VII

Concentration of Sr^{90} in the deep waters
of the Atlantic Ocean

Data	Coordinates	Horizon m	Sr^{90} act- ivity dis/min per 100 litres	Stooks of Sr^{90} in the explored layer, micro- curies/sq.km
4.04.61	00°17' n.lat 20°19' w.long	0	13	
5.04.61		30	16	6.2
4.04.61		50	17	
4.04.61		100	7	
7.05.61	20°01' S.lat 30°03' w.long	0	5	
		0	7	3.2
		30	8	
		50	7	
		100	7	
12.06.61	11°01' n.lat 29°56' w.long	0	16	
		30	9	4.4
		100	7	
16.10.62	60°12' n.lat 01°39' w.long	0	38	
20.10.62	38°22' n.lat 10°16' w.long	0		26
18.10.62	44°40' n.lat 9°17' w.long	70	24	
18.10.62	44°40' n.lat 9°17' w.long	200	31	
20.10.62	38°22' n.lat 10°16' w.long	0	24	
		500	9	64
		1000	13	
26.10.61	20°29' n.lat 17°27' w.long	0	17	
31.10.62	10°00' n.lat 17°55' w.long	25	15	3.3
		50	11	
31.10.62	10°00' n.lat 17°55' w.long	0	21	
		50	11	9.4
		200	6	
08.11.62	01°05' n.lat 18°10' w.long	0	27	
06.11.62	01°00' S.lat 18°00' w.long	50	12	
07.11.62	00°05' n.lat 18°16' w.long	85	29	16
		190	11	
		200	11	

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II.II.62	01°00' S.lat	25°10' w.long	0	33	
			100	14	36
			500	14	
28.II.62	16°00' S.lat.	33°21' w.long	0	17	
			100	6	32
			800	6	
17.I2.62	00°52' n.lat	25°27' w.long	0	10	
			50	10	13
			300	8	

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